REMARKS

Claims 19, 21-27, 30-32, 38, 41, 43, 44, 47-49, and 51-61 are currently pending. Claims 30-32 have been withdrawn. Claims 1-18, 20, 28, 29, 33-37, 39, 40, 42, 45, 46, and 50 have been canceled. Claims 21-27, 47-49, and 51 have been amended for clarification purposes only because the claims they had depended have been canceled. Claims 19, 38, 41, 43, and 44 have been amended, the amendment of which is supported by page 6, line 17, through page 7, line 5, page 8, line 18, through page 9, line 2, page 9, line 15, through page 12, line 13, and Figures 3 and 4. Claims 54-61 have been added and are supported by page 6, line 10, through page 7, line 1, and page 11, line 3, through page 12, line 13. It is respectfully submitted that no new matter has been added.

It may also be beneficial to remind the Patent Office of MPEP § 2163.07(a) which relates to inherent function, theory, or advantage.

> By disclosing in a patent application a device that inherently performs a function or has a property, operates according to a theory or has an advantage, a patent application necessarily discloses that function, theory or advantage, even though it says nothing explicit concerning it. The application may later be amended to recite the function, theory or advantage without introducing prohibited new matter. In re Reynolds, 443 F.2d 384, 170 USPQ 94 (CCPA 1971); In re Smythe, 480 F. 2d 1376, 178 USPQ 279 (CCPA 1973). "To establish inherency, the extrinsic evidence 'must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.'" In re Robertson, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999) (citations omitted).

The Patent Office has asserted in the PTO-90C Communication dated January 5, 2007:

> Receipt is acknowledged of a request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17 (e) and a submission, filed on 10-13-6 and 9-18-6, respectively. The submission, however, is not fully responsive to the prior Office action because it presents claims for a different invention. In particular, it presents claims to the species excluding TiN and TaN which is independent and distinct from the species not

excluding TiN and TaN previously claimed and examined. Since the submission appears to be a *bona fide* attempt to provide a complete reply to the prior Office action…

The independent claims were amended to further limit the claimed invention in the response filed on September 18, 2006. Only one invention had been claimed and is currently claimed. The further limitation of the claims is not an election by original presentation nor is it the selection of a non-examined species. Under the statute, the claims of an application may properly be required to be restricted to one of two or more claimed inventions only if they are able to support separate patents and they are either independent (MPEP § 802.01, § 806.06, and § 808.01) or distinct (MPEP § 806.05 - § 806.05(j)) (see MPEP 803). The term "independent" (i.e., unrelated) means that there is no disclosed relationship between the two or more inventions claimed, that is, they are unconnected in design, operation, and effect (see MPEP 806.01). Related inventions are distinct if the inventions as claimed are not connected in at least one of design, operation, or effect (e.g., can be made by, or used in, a materially different process) and wherein at least one invention is patentable (novel and nonobvious) over the other (though they may each be unpatentable over the prior art) (see MPEP 806.01). Species may be either independent or related under the particular disclosure. Where species under a claimed genus are not connected in any of design, operation, or effect under the disclosure, the species are independent inventions (see MPEP 806.04 (b)). The claimed invention is a multi-layer structure that inhibits diffusion of a chemical species through the multi-layer structure. Regardless as to whether the individual layers include TiN or TaN or exclude these materials, the claimed invention would have the same structure, similar or the same operation, and similar or the same effect, so a claimed embodiment including TiN and TaN and a claimed embodiment excluding TiN and TaN would not be independent.

To facilitate prosecution, the claimed subject matter that was objected to has been removed from the independent claims to dependent claim 60.

Claim 38 is rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. Claims 19, 20, 26, 28, 29 and 38-53 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent 6,136,682 to Hegde et al. and, alternatively, under 35 U.S.C. § 103(a) as being obvious in view of Hegde et al.

Claims 21 and 23-25 are rejected under 35 U.S.C. § 103(a) as being obvious over

Hegde et al. as applied to claim 20, and further in combination with U.S. Publication 20030227068 by Li. Claims 19, 20 and 22 are also rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Publication 20040026119 by Chen. Claim 27 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Hegde et al. as applied to claim 20, and further in combination with U.S. Patent 6,828,189 to Igarashi.

The foregoing rejections are respectfully disagreed with, and are traversed below.

Claim 38 has been further clarified to recite "the films" in line 3. Thus, the Examiner's rejection under 35 USC § 112, second paragraph, should be reconsidered and withdrawn.

Independent claim 19 has been further clarified to specify that each sub-layer has a thickness of about 0.4 to about 1.5 nm. This claim has also been clarified to specify that the sub-layers are comprised of alternating layers of at least two different materials and the at least two materials selected to comprise the sub-layers are substantially immiscible and exhibit mutual adhesion, and the overall thickness of the barrier is between about 30 and 50 angstroms.

Support for the foregoing exists in the specification as follows: Page 6 discloses copper is able to diffuse through the grain boundaries 215 in these materials 230 and 235. The next paragraph of the specification details acceptable materials for Applicant's alternating layers of materials.

Pages 7-8 of the specification disclose the unexpected benefit of employing 0.4-1.5 nm thick sub-layers. As disclosed therein, the resulting structure has the form of an essentially or substantially amorphous material thereby beneficially inhibiting diffusion through the material. Page 8 also specifies that the overall thickness of the barrier is preferably between 30 and 50 angstroms.

Pages 9-10 of Applicants' specification further discloses that two considerations include that the two materials are preferably immiscible or have at most only a very minor level of solubility, and preferably exhibit good mutual adhesion.

Claims 21-27 depend from claim 19 and recite further advantageous features of the claimed diffusion barrier.

Independent claim 38 has also been further clarified to specify that the each film is in a range of about 0.4 to about 1.5 nm, wherein the films are comprised of alternating layers of at least two different materials and the at least two materials selected to

comprise the films are substantially immiscible and exhibit mutual adhesion.

Similarly, independent claims 41 and 44 have been clarified to specify a sub-layer or film thickness of about 0.4 to about 1.5 nm each. Claim 44 further specifies that at least one of the materials is a dielectric material and thus claim 50 has been canceled.

Support for the foregoing clarification is, for example, as described above for claim 19.

Claims 47-49 and 51-53 depend from independent claim 44 and recite further advantageous features of the claimed structure.

Regarding the rejections based upon art, it is respectfully asserted that the cited references, whether viewed alone or in any combination, do not disclose nor suggest the subject claims for at least the following reasons.

In particular, Hegde et al. disclose a TiN layer deposited over a TaN layer. A copper material is then deposited over the TiN layer (Abstract). As further disclosed at col. 3, lines 59-67, 0-200 angstroms define the TiN amorphous barrier region and 200-400 angstroms define the TaN or TaSiN layer. Preferably, the TaN or TaSiN layer is between 20 angstroms and 200 angstroms, as disclosed at col. 4, lines 42-52. At col. 2, line 65- col. 3, line 5, Hegde et al. state that the TaN "deposits in an amorphous state" and at col. 4, lines 48-53 Hegde et al. refer to physical vapor deposition.

The subject claims do not relate to TiN/TaN deposition as in Hegde et al., and thus Hegde et al. do not disclose or suggest any of Applicants' claims. Moreover, although Hegde et al. mention amorphous deposition, there does not appear to be any teachings as how to achieve amorphous deposition and thus Hegde et al. is not sufficiently enabling.

Additionally, at col. 3 Hegde et al. cite experiments and assert that there is an unexpected benefit of a 400 angstrom composite of TiN and TaN. In contrast, Applicants claim a thickness between about 30 and about 50 angstroms (see, e.g., claim 1), which is significantly less than that of Hegde et al.

Applicants again respectfully assert that unexpected results are present as a result of the claimed invention. For example, in contrast to Hegde et al. and as disclosed in the specification at page 4, Applicants have determined how to form a very thin, multilayer diffusion barrier composed of even thinner sub-layers, where the sub-layers are only a few atoms thick. A strong bond between each of the sub-layers perturbs the regular

crystalline structure of the sub-layer, as long as the sub-layer remains very thin. Since the surface energies dominate the bulk binding energies, the sub-layer remains disordered and essentially free of a regular crystalline structure. The lack of formation of a lattice within each sub-layer results in no grain boundary formation, and hence, no pathways for inter diffusion through the barrier.

Hegde et al. do not disclose or suggest such a barrier including, for example, each sub-layer having a specific thickness between about 0.4 and about 1.5 angstroms, wherein formation of crystalline lattice and diffusion of a chemical species through the barrier is inhibited. Hegde et al. particularly teach that "unexpected results" are obtained with a 400 angstrom composite. There is no description in Hegde et al. of the claimed structure at the claimed nanometer scale.

Nor does this reference disclose or suggest the claimed multilayer diffusion barrier including the afore-referenced film thickness, wherein the surface adhesion of each interface inhibits the formation of a lattice in the individual film layers inhibiting diffusion across the barrier, or comprising alternating films of at least two different metals wherein work hardening is substantially eliminated. Nor is the particularly claimed multilayer structure of the claimed thickness disclosed or suggested.

The addition of Li et al., Chen and/or Igarashi does not cure the shortcomings of Hegde et al. for at least the following reasons. Li et al. relate to a sputtering target. While Li et al. may generally mention a grain size less than 1 nm, Li et al. do not disclose or suggest any structure including the particularly claimed thin layers, wherein formation of a crystalline lattice is inhibited.

Chen discloses a semiconductor device including a barrier layer comprising an amorphous metallic glass. Chen does not disclose any structure as claimed herein including the specified sub-layers. Paragraph 25 of Chen describes an amorphous metallic glass barrier and its effect on surface free energy, which allows the next layer deposited to be more textured. In paragraph 26, Chen discloses a layered structure of the preferred layer of amorphous metallic glass and additional layers of a variety of compounds of nitrides and carbides, which do not appear to be described as amorphous. Furthermore, Chen clearly discloses that the sub-layers or films of the barrier layer 5 are at least 5.0 nanometers thick (e.g., paragraphs 0020-0021).

Accordingly, Chen is prior art under 35 U.S.C. 103(a) and not under 35 U.S.C.

102. Chen is disqualified as prior art because Chen was commonly owned and assigned or subject to assignment to Applicant at the time Applicant's invention was made and Chen qualifies as prior art only under one or more of 35 U.S.C. 102(e), (f), or (g). (See MPEP § 706.02(l)(1).)

Lastly, Igarashi relates to the blocking of hydrogen diffusion with the use of oxide films and was particularly cited by the Examiner as disclosing tantalum oxide. This disclosure in combination with any/all of the afore-cited references does not disclose or suggest the claimed invention for the reasons set forth above.

In view of the foregoing, it is asserted that there is no teaching or suggestion that would motivate one of ordinary skill in the art to combine and modify the cited references in an attempt to arrive at the subject claims. Without such a teaching, suggestion or motivation, the invention may only be considered obvious in hindsight, which is an improper basis for rejection.

All issues having been addressed, the subject patent application is believed to be in condition for immediate allowance. No new issues requiring a further search are presented and thus the Examiner is requested to enter and consider and Amendent. Accordingly, the Examiner is respectfully requested to reconsider and remove the outstanding rejections and objection. An early notification of the allowance is earnestly solicited.

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